signal serves as input ot a frame grabber (not shown) located in the main workstation PC (not shown).

Operational Modes of the Optical Transport System

It is clear from FIG. **1A**, that when all the OBIM's **115** operate at the same wavelength, the system **111** functions as a Bus in the Broadcast Mode. Referring to FIG. **4H**, if different wavelengths are assigned to different nodes, although some nodes can transmit and receive multiple wavelengths, the topology is equivalent to a non-blocking Star configuration using MUX/DEMUXes with as many as 128 wavelengths employing current technology wherein the maximum number of wavelengths is determined by the allowable cross-talk between channels, the laser line width, the optical amplifier pass band and the information bandwidth.

The present invention is not limited to fixed wavelengths. In fact, the present invention operates as a non-blocking logical switch if all nodes have their transmitters and receivers tunable. The operation is as follows: if a node want to transmit to a set of nodes on a specific wavelength and the transmitting node tunes its laser to that wavelength, the receiving nodes tune their receivers to the same wavelength. Tunable filters, whether electro-optical, acouto-optical or opto-mechanical can be inserted in the receivers in lieu of fixed filters in order to vary the wavelength assignment on a packet-to-packet basis as well as to provide dynamic routing.

If some OBIM's **115** are altered to be configured as in FIG. **4I** by using dichroic (also known as WDM) couplers **116** and the corresponding nodes are assigned the same wavelength (in this example 1310 nm), the resulting topology for these nodes is that of a Point-to-Point Repeatered Link. This is equivalent to a ring topology, and although the ring is broken, all nodes communicate with each other because of the bi-directionality of the OBIM's **115**. In this example, the repeater links use an ATM (asynchronous transfer node) protocol.

Optimum System Topology

The optimum bus interface topology is illustrated in FIG. **5** with the specific coupler ratios 80/20 on-line and 50/50 off-line. As an example, the received signal at node n from node **1** is:

$$(0.5)(0.5)(0.2)[(0\ 2)(0.5)](0.8)^{n-2}=0.00125(0.8)^{n-2}=-23\text{ dB}$$

Optimum coupling is a function of the number of nodes. Calling the on-line coupling ratio c and the off-line coupling ratio k where c and k correspond to the cross states and (1−c), (1−k) are the bar states, the bus is assigned arbitrary coupling c and k. Deriving the optimum coupling ratios by calculating the received signals at both extreme nodes as follows:

Received signal at node n from node 1: Bus 1 or Bus 2: $k^3(1-c)(1-c)(c)^{n-2}=k^3(1-c)^2(c)^{n-2}$ where n=number of nodes.

To ensure same signal strength at both nodes,

$k=1-k$ $k=50\%$

Thus, the received signal at either node receiver contributed by either bus is: $S=0.125(c)^2(1-c)^{n-2}$. The optimum coupling as a function of nodes is obtained by setting ds/dc=0 which yields c=2/n.

Referring to FIG. **6**, a plot is shown of the optimum in-line coupling c_{opt} vs n, where n is the number of nodes. For the minimum number of two nodes, we find the optimum coupling ratio is 1, indicating all the light from node **1** transmitter is received at node **2** receiver. Since the maximum number of nodes the system **111** can sustain without optical amplifiers is approximately n less than or equal to 10, the best ratio is 80%, or alternatively, 20% is tapped from the bus signal at each node.

As noted above, the OBIM **115** provides the optical interface between the avionics cable plant and the EOIC **117**. A small rugged enclosure complete with moisture seals ensures a benign mechanical environment for the couplers, splices, and fiber pigtails and also provides an area for excess fiber storage and restraint to minimize fiber vibration and hence fracture and breakage. The proposed package shown in FIG. **7** is made of 6661T6 aluminum with machined grooves for capturing the couplers and fiber splices and a cross member to provide position stability. An "O" ring groove provides a vapor seal in conjunction with the aluminum cover secured by 10 machining screws. The enclosure body measure 4.5 inches in length by 2.5 inches wide and 1.0 inches high including the 0.10 inch thickness cover. Anodizing of the enclosure increases corrosion resistance.

FIG. **8** illustrates component placement for a Mil_Std **1553** type card. The card size is approximately 6 inches by 4 inches and shows the location of all components identified with respect to the block diagram discussed above. Heat sinks are provided to dissipate heat generated by the thermoelectric devices bonded to the DFB lasers. Ample area for fiber pigtails avoid excess minimum bend radius requirements and tie down areas for the optical components allocated.

What is claimed is:

1. A bi-directional, redundant, optical transport system configured to provide a non-blocking, bi-directional, multichannel, protocol independent optical transport system for the simultaneous transfer of digital, analog, and discrete data between a plurality data terminal equipment, the optical transport system comprising:

- a light transmission line for transmitting light bi-directionally;
- a plurality of nodes, connected in series by the light transmission line for receiving, extracting and passing signal light, each node comprising:
  - data terminal equipment for issuing and receiving electrical signals;
  - an electro-optical interface device, associated the data terminal equipment, for converting electrical signals issued by the associated data terminal to it signal light for insertion onto the light transmission light and for converting signal light, extracted from the light transmission line into electrical signals to be received by the associated data terminal;
  - a translation logic device connected between the electrical optical interface device and the data terminal equipment, for performing required protocol translation for the data terminal equipment
  - an optical interface device, connected to the electro-optical interface device and the light transmission line, for extracting signal light from the light transmission line to be converted into electrical signals by the electro-optical interface device for receipt by the data terminal equipment, for inserting, onto the light transmission line, signal light received from the electro-optical interface device and for passing signal light bi-directionally on the light transmission line;
- a pump source for inserting excitation light onto the light transmission line;
- an optical amplifier connector fiber connecting the cach of the optical interface devices serially to one another, wherein the optical amplifier connector fiber is doped

with a material which is excited by the excitation light and which emits light having a same wavelength as the light signals when radiated with light signals transmitted bi-directionally by the at least one fiber optic line.

2. An optical transport system according to claim 1, wherein the data terminal equipment comprises one of a computer, video or telephone device, having different protocol requirements.

3. An optical transport system according to claim 1, wherein the pump source is a pump laser which emits excitation light.

4. An optical transport system according to claim 3, wherein the excitation light emitted by the pump laser has a wavelength of about 980 nm.

5. An optical transport system according to claim 4, wherein the signal light has a wavelength of about 1550 nm.

6. An optical transport system according to claim 5, wherein the connector fiber is doped with erbium.

7. An optical transport system according to claim 6, wherein the length of the optical amplifier connector fiber is set as a function of the amount of amplification required.

8. An optical transport system according to claim 7, wherein the length of the optical amplifier connector fiber is about two meters.

9. An optical transport system according to claim 1, wherein the optical interface device comprising:

a first optical coupler for receiving signal light to be inserted onto or extracted from the light transmission line; and

a fiber optic-line, optical coupler, coupled to the light transmission line and to the first optical coupler, for passing light on the light transmission line, for receiving light from the first optical coupler to be inserted onto the light transmission line and transmitting said received light in opposite directions on the light transmission line, and for extracting light from opposite directions on the light transmission line and transmitting said extracted light to the first optical coupler.

10. An optical transport system according to claim 9 wherein the first optical coupler is a four port, bi-directional optical coupler.

11. An optical transport system according to claim 10, wherein the first optical coupler has:

first and second ports for receiving light to be inserted onto the light transmission line and for transmitting light extracted from the light transmission line, and

third and fourth ports each respectively connected to the fiber optic-line, optical coupler;

wherein light received by at least one of the first and second ports is split by the first optical coupler and transmitted by both the third and fourth ports to the light transmission line in opposite directions by the fiber optic-line, optical coupler; and

wherein light extracted from the light transmission line by the fiber optic-line, optical coupler and received by at least one of the third and fourth ports is split by the first optical coupler and transmitted by the both the first and second ports.

12. An optical transport system according to claim 11, wherein the fiber optic-line, optical coupler is a pair of fiber optic-line, optical couplers comprising first and second fiber optic-line, optical couplers, the first fiber optic-line, optical coupler comprising:

a first port for receiving light transmitted in a first direction on the light transmission line and for transmitting light received from either the second fiber optic-line,

optical couplers or the first optical coupler to the light transmission line in a second direction opposite to said first direction;

a second port for transmitting light received from the light transmission line in said first direction by the first port to the second fiber optic-line, optical coupler and for receiving light in said second direction from the second fiber optic-line, optical coupler; and

a third port for transmitting light received from the light transmission line by the first port in the first direction to the first optical coupler;

wherein light received by the first port of the first fiber optic-line, optical coupler is split by the first fiber optic-line, optical coupler and transmitted by both the second and third ports; and

the second fiber optic-line, optical coupler comprising:

a fourth port for receiving light transmitted in the second direction on the light transmission line and for transmitting light received from first optic line optical coupler or the first optical coupler to the light transmission line in the first direction;

a fifth port for transmitting light received from the light transmission line in second direction by the fourth port to the first fiber optic-line, optical coupler and for receiving light in the first direction from the first fiber optic-line, optical coupler; and

a sixth port for transmitting light received from the light transmission line in the first direction by the fourth port to the first optical coupler;

wherein light received by the fourth port of the second fiber optic-line, optical coupler is split by the second fiber optic-line, optical coupler and transmitted by both the fifth and sixth ports.

13. An optical transport system according to claim 1, wherein the light transmission line comprises first and second fiber optic lines.

14. An optical transport system according to claim 13, wherein the optical interface device comprises:

a first optical coupler for receiving light to be inserted onto or extracted from the first fiber optic line;

a pair of first fiber optic-line, optical couplers, each coupled to the first fiber optic line and to the first optical coupler, for passing light on the first fiber optic line, for receiving light from the first optical coupler to be inserted onto the first fiber optic line and transmitting said received light in opposite directions on the first fiber optic line, and for extracting light from opposite directions on the first fiber optic line and transmitting said extracted light to the first optical coupler;

a second optical coupler for receiving light to be inserted onto or extracted from the second fiber optic line; and

a pair of second fiber optic-line, optical couplers, each coupled to the second fiber optic line and to the second optical coupler, for passing light on the second fiber optic line, for receiving light from the second optical coupler to be inserted onto the second fiber optic line and transmitting said received light in opposite directions on the second fiber optic line, and for extracting light from opposite directions on the second fiber optic line and transmitting said extracted light to the second optical coupler.

15. An optical transport system according to claim 14, wherein the first and second optical couplers are each a four port, bidirectional optical coupler.

16. An optical transport system according to claim 15, wherein the first optical coupler has:

first and second ports for receiving light to be inserted onto the first fiber optic line and for transmitting light extracted from the first fiber optic line, and

third and fourth ports each respectively connected to one of the pair of first fiber optic-line, optical couplers;

wherein light received by at least one of the first and second ports is split by the first optical coupler and transmitted by both the third and fourth ports in opposite directions on the first fiber optic line by the pair of first optic line optical couplers; and

wherein light extracted from the first fiber optic line and received by at least one of the third and fourth ports is split by the first optical coupler and transmitted by the both the first and second ports; and

wherein the second optical coupler has:

first and second ports for receiving light to be inserted onto the second fiber optic line and for transmitting light extracted from the second fiber optic line, and

third and fourth ports each respectively connected to one of the pair of second fiber optic-line, optical couplers;

wherein light received by at least one of the first and second ports is split by the second optical coupler and transmitted by both the third and fourth ports to the second fiber optic line in opposite directions by the pair of second fiber optic-line, couplers; and

wherein light extracted from the second fiber optic line and received by at least one of the third and fourth ports is split by the second optical coupler and transmitted by the both the first and second ports.

17. An optical transport system according to claim **16**, wherein the pair of first fiber optic-line, optical couplers comprise first and second fiber optic-line, optical couplers, the first fiber optic-line, optical coupler comprising:

a first port for receiving light transmitted in a first direction on the first fiber optic line and for transmitting light received from either the second fiber optic-line, optical coupler or the first optical coupler to the first fiber optic line in a second direction opposite to said first direction;

a second port for transmitting light received from the first fiber optic line in said first direction by the first port to the second fiber optic-line, optical coupler and for receiving light in said second direction from the second fiber optic-line, optical coupler; and

a third port for transmitting light received from the first fiber optic line by the first port in the first direction to the first optical coupler;

wherein light received by the first port of the first fiber optic-line, optical coupler is split by the first fiber optic-line, optical coupler and transmitted by both the second and third ports; and

the second fiber optic-line, optical coupler comprising:

a fourth port for receiving light transmitted in the second direction on the first fiber optic line and for transmitting light received from first optic line optical coupler or the first optical coupler to the first fiber optic line in the first direction;

a fifth port for transmitting light received from the first fiber optic line in second direction by the fourth port to the first fiber optic-line, optical coupler and for receiving light in the first direction from the first fiber optic-line, optical coupler; and

a sixth port for transmitting light received from the first fiber optic line in the first direction by the fourth port to the first optical coupler;

wherein light received by the fourth port of the second fiber optic-line, optical coupler is split by the second fiber optic-line, optical coupler and transmitted by both the fifth and sixth ports; and

wherein the pair of second fiber optic-line, optical couplers comprise third and fourth fiber optic-line, optical couplers, the third fiber optic-line, optical coupler comprising:

a first port for receiving light transmitted in a first direction on the second fiber optic line and for transmitting light received from either the fourth fiber optic-line, optical coupler or the second optical coupler to the second fiber optic line in a second direction opposite to said first direction;

a second port for transmitting light received from the second fiber optic line in said first direction by the first port to the fourth fiber optic-line, optical coupler and for receiving light in said second direction from the fourth fiber optic-line, optical coupler; and

a third port for transmitting light received from the second fiber optic line by the first port in the first direction to the second optical coupler;

wherein light received by the first port of the third fiber optic-line, optical coupler is split by the third fiber optic-line, optical coupler and transmitted by both the second and third ports; and

the fourth fiber optic-line, optical coupler comprising:

a fourth port for receiving light transmitted in the second direction on the second fiber optic line and for transmitting light received from third optic line optical coupler or the second optical coupler to the second fiber optic line in the first direction;

a fifth port for transmitting light received by the fourth port from the second fiber optic line in second direction to the third fiber optic-line, optical coupler and for receiving light in the first direction from the third fiber optic-line, optical coupler; and

a sixth port for transmitting light received from the second fiber optic line in the first direction by the fourth port to the second optical coupler;

wherein light received by the fourth port of the fourth fiber optic-line, optical coupler is split by the fourth fiber optic-line, optical coupler and transmitted by both the fifth and sixth ports.

18. An optical transport device according to claim **1**, wherein the light transmission line comprises more than two fiber optical lines.

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